

knowledge. Another appendix deals with the proposed explorations and investigations on a large scale, and is contributed to by several well-known American men of science.

A STRIKING illustration of the enormous advance that has taken place in chemical manipulation during the past two or three years is afforded by a paper, in a recent number of the *Berichte*, on the "Evaporation and Boiling of Metals in Quartz-glass and in the Electric Furnace in the Vacuum of the Kathode-light." Dr. F. Krafft there states that the quartz tubes could be safely heated to 1200° , and with care up to 1400° C., even when exhausted to the low pressure required for the production of the kathode-light in a vacuum tube, and that even when containing metals they could be safely taken from the furnace at 1200° , allowed to cool in the air without annealing; and then replaced in the furnace without any risk of fracture. By using an electric furnace it was possible not only to regulate the temperature within 2° or 3° between 18° and 1400° C., but also to connect the quartz tubes to the pump by means of a ground-glass joint made tight with wax, the wax remaining unmelted although within a few inches of the hottest part of the furnace.

THE results achieved by the methods described in the foregoing note were remarkable. The only vapour in the quartz tube was that of the metal, which extended from the surface of the liquid to the top of the furnace, above which condensation took place. Under this almost inconceivably low pressure cadmium boiled at 420° , i.e. below the boiling point of sulphur, zinc at 545° , and bismuth below 1000° , the temperature of the furnace being about 150° above that of the boiling metal. Lead could be rapidly distilled with a furnace temperature of 1180° , and antimony at $775-780^{\circ}$. Silver began to evaporate fairly rapidly at 1200° , but did not boil at 1340° ; copper showed a distinct, though slight, evaporation at 1315° , but gold, even at 1375° , the highest temperature reached in the experiments, gave only a small mirror of silver, and below it a tiny distillate of gold weighing less than 2 mg. It is of interest to note that the boiling points in an absolute vacuum of these metals, which probably lie at about 1400° , 1600° , and 1800° respectively, are in the order of increasing valency, and not in the order of their atomic weights.

THE additions to the Zoological Society's Gardens during the past week include a Sooty Mangabey (*Cercocebus fuliginosus*), a Green Monkey (*Cercopithecus callitrichus*) from West Africa, presented by Mr. C. S. Birch; a Two-spotted Paradoxure (*Nandinia binotata*), two Senegal Touracous (*Turacus persa*) from West Africa, presented by Mr. James Drew; a Ring-tailed Coati (*Nasua rufa*) from South America, presented by the Hon. Sibyl Edwards; a Patagonian Cavy (*Dolichotis patachonica*) from Patagonia, presented by Sir E. G. Loder; a Common Quail (*Coturnix communis*), British, presented by Mr. J. Woodward; an Adanson's Sternotherer (*Sternotherus adansonii*) from West Africa, a Pale Lizard (*Agama pallida*), an Egyptian Eryx (*Eryx jaculus*), a Blunt-nosed Snake (*Tarbophis obtusus*), a Schokari Sand Snake (*Psammophis schokari*), a Diadem Sand Snake (*Lytrohynchus diadema*) from North Africa, presented by Captain Stanley Flower; a Stair's Monkey (*Cercopithecus stairsi*) from British East Africa, a Green Monkey (*Cercopithecus callitrichus*), an Eroded Cinixys (*Cinixys erosa*) from West Africa, a Black-headed Lemur (*Lemur brunneus*), a Grey Lemur (*Hapalemur griseus*) from Madagascar, five Grey Monitors (*Varanus griseus*), five Spiny-tailed Mastigures (*Uromastix acanthinurus*), eight Ocellated Sand Skinks, a Corais Snake (*Coluber*

corais) from South America, a King Snake (*Coronella getula*), a Mocassin Snake (*Tropidonotus fasciatus*) from North America, a Carpet Python (*Python variegata*) from Queensland, a Rhesus Monkey (*Macacus rhesus*, var.), two Indian Rat Snakes (*Zamenis mucosa*) from India, deposited; a Burrhel Wild Sheep (*Ovis burrhel*), an Axis Deer (*Cervus axis*), born in the Gardens.

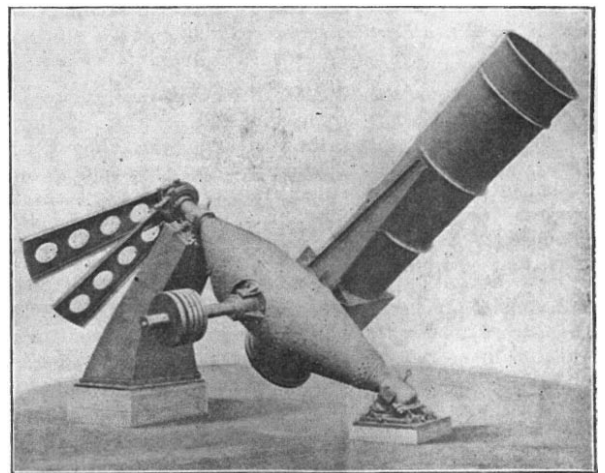
OUR ASTRONOMICAL COLUMN.

CONNECTION BETWEEN SUN-SPOTS AND ATMOSPHERIC TEMPERATURE.—M. Charles Nordmann has recently completed a discussion of the effect of sun-spots on the mean annual temperature of the earth's atmosphere in tropical regions. The period under discussion extends from 1870 to 1900, and the method of discussion is analogous to that published by Köppen in 1873, which dealt with the period 1830 to 1870.

M. Nordmann has compared the mean annual variations of temperature from the normal, as obtained from the observations made at thirteen tropical stations situated in various longitudes, with Wolf's numbers for sun-spot frequencies during the same period, and from the two curves obtained by plotting the two sets of numbers he has arrived at the following conclusion:—"The mean terrestrial temperature follows a period sensibly equal to that of solar spots; the effect of spots is to diminish the mean temperature, i.e. the curve which represents the variations of temperature is parallel to the inverse curve of sun-spot frequencies (*Comptes rendus*, No. 18).

THE CROSSLEY REFLECTOR OF THE LICK OBSERVATORY.—This reflector, it will be remembered, was presented to the Lick Observatory by Mr. Crossley, of Halifax, Yorks, and contains one of the splendid mirrors made by the late Dr. Common. It has an aperture of 3 feet, and a focal length of 17 feet 6 inches. When remounted and used at Lick it was found that the instrument was unsuitable for long exposures on account of flexure and other defects, therefore a new mounting has been devised and constructed by Messrs. Harron, Rickard and McCune, of San Francisco, and is found to work satisfactorily.

The polar axis is 14 feet long, and is so raised as to allow the instrument to be used in all positions. As shown in the accompanying illustration, this axis rests on two piers, the northern one consisting of an inclined steel



pillar, 8 feet high, resting on a concrete and brick foundation which is 6 feet high, whilst the bearing on the southern end, carrying the altitude and azimuth adjustments, rests directly on the brick and concrete foundation, the downward thrust being borne by hardened steel balls. The telescope tube is carried by the strong steel declination axis, and the mirror is contained by a cast-iron cell in the lower cylindrical section of the steel tube, whilst the photographic plate holder, with the usual adjustments, is placed

at the focus of the mirror and in the optical axis of the same.

The driving motion of the clock is transmitted to the telescope by two sectors, one of which is being run back ready to be put into gear again whilst the other is being used; each sector allows of one hour's exposure being made. The "following" is performed by means of an auxiliary telescope rigidly attached to the plate holder (*Scientific American*, May 16).

THE RELATIONSHIPS BETWEEN ARC AND SPARK SPECTRA.—In No. 4, vol. xvii. of the *Astrophysical Journal* there appears an advance translation, by the author, of a paper on the above subject recently communicated to the K. Akademie der Wiss. zu Berlin by Prof. J. Hartmann.

In his experiments on the arc spectrum of magnesium, using metallic poles, he found that the line at λ 4481, which is generally regarded as essentially a "spark" line, appears in the arc spectrum, and actually increases in intensity as the current strength becomes less: this is plainly shown in a table which accompanies the paper. From this and similar results the author arrives at the conclusion that the higher temperature of the spark, as compared with that of the arc, is open to question.

Further experiments showed that a high voltage was not necessary for the production of "spark" lines in the arc, for when a current of 20 volts and 4 amperes was used the line 4481 was about thirty times more intense than when 120 volts and 4 amperes were used.

Prof. Hartmann arrives at the conclusion that the energy of the electric discharge and of the chemical changes may play a more important part in the production of "spark" lines than temperature does, and in his experiments, in which the arc was formed in an atmosphere of hydrogen, he has shown that the dielectric is also an important factor in determining the nature of the spectrum obtained.

RADIO-ACTIVE PROCESSES.¹

THERE are three distinct types of radiation spontaneously emitted from radio-active bodies, which may be called the α , β , and γ rays. The α -rays are prominent in causing the conductivity of a gas, they are easily absorbed by metals, and are projected bodies, not waves. These bodies are about the size of a hydrogen atom, they are positively charged, and travel with about one-tenth of the velocity of light. The β -rays are similar in all respects to the cathode rays produced in a vacuum-tube. The γ -rays are probably like Röntgen rays, but of very great penetrating power. The α -rays are by far the most important. In addition to these rays two of the radio-elements give off radio-active "emanations," which are in all respects like gases. The radiations from these emanations are not permanent, but fall off in a geometrical progression with the time. The radiation of the thorium emanation falls to half value in one minute, that from radium in four days. They have all the properties of gaseous matter in infinitesimal quantity. Their coefficients of diffusion can be measured, the order of their molecular weights is 100, they are occluded by solid compounds producing them, and may be condensed at low temperatures. The radium emanation condenses sharply at -150° C., the thorium emanation between -120° C. and -150° C. The two emanations excite on objects with which they come in contact two kinds of temporary radio-activity, that from the radium emanation decaying much faster than that from the thorium emanation. The latter decays in a G.P. with the time falling to half value in eleven hours. These effects appear to be produced by solid matter in invisible and unweighable quantity, which can be dissolved off in some acids but not in others. On evaporating the solutions, the radio-activity is obtained unchanged in the residue. The experiments of Crookes and Becquerel in separating by chemical treatment the matter responsible for the activity of uranium, called uranium X, were referred to, together with the latter's observation that the separated activity had completely decayed after the lapse of a year, by which time the uranium itself had completely recovered its activity. The work of Rutherford and

Soddy on thorium was then discussed in detail. Thorium precipitated in solution by ammonia retains only 25 per cent. of its activity. If the solution is evaporated and ignited the remaining 75 per cent. is found in the extremely small residue left, which by reason of its separation is different chemically from thorium, and was called thorium X. Left to themselves, the thorium gradually recovers its activity, and the ThX loses it. The activity of the latter falls in a G.P. with the time, the half value being reached after four days. At any time the sum total of the two activities is a constant. This would occur if the ThX were being continually produced by the thorium, and this was shown to be the case by precipitating thorium at definite intervals after its separation from ThX. The ThX, and not thorium, produces the thorium emanation. The production of ThX by thorium, of the emanation by ThX, and of the matter causing the excited activity by the emanation, are all changes of the same type, although the rates of change are distinct in each case. The change of uranium into uranium X is also similar, being the slowest of all. Twenty-two days elapse before uranium freed from ThX recovers one-half of its activity. In radium the radium emanation is the first product produced, and since this in a solid is almost completely occluded, the activity of a radium salt after it has been obtained from its solution rises after precipitation to several times its original value, due to the occlusion of the emanation. In all three radio-elements a part of the radio-activity is non-separable, and this part consists only of α -rays. The β -rays only result at the last stages of the process that can be experimentally traced. In all cases the radiation, from any type of active matter, is a measure of the amount of the next type produced. Thus the radio-activity of ThX at any period throughout its life is always a measure of the amount of emanation it produces. These results find their explanation if it is supposed that the α -particles projected form integral portions of the atom of the radio-active element. Thus ThX is thorium minus one or more projected α -particles. The emanation similarly is ThX less a further α -particle, and so on. The non-separable activity is due to the atoms of the original radio-element disintegrating at a constant rate. The whole of the processes take place unaltered in velocity, apparently under all conditions of temperature, state of aggregation, and chemical combination. This is to be expected of a subatomic change in which one system only is involved at each change. On this view the spontaneous heat-emission of solid radium salts, discovered by Curie, is explained by the internal bombardment by the α -particles shot off and absorbed in the mass of the substance. The amount of energy given out in these subatomic changes is enormous, and from Curie's experiments it can be deduced that each gram of radium gives out 10^9 gram-calories during its life, which is sufficient to raise 500 tons a mile high. It seems probable that the internal energy of atoms in general is of a similar high order of magnitude.

SOME UNSOLVED PROBLEMS IN ENGINEERING.¹

THE present lecture is devoted to the indication of some of the directions in which the further aid of the physicist is more immediately required by the engineer, while it is hoped that in future lectures each branch of inquiry thus pointed out will be dealt with in detail by someone who has made that particular subject his special study.

In view of the great interests—monetary and otherwise—involved, it appears to me that the whole question of steam-jacketing, and particularly the application of such jackets to compound or multiple-expansion engines of modern types and of large power, using steam at high pressures, deserves a much more thorough and systematic investigation than it has hitherto received.

The action of steam-jackets is, however, only one of several important problems relating to steam-engine economy at present remaining unsolved. Another is the

¹ Abstract of paper read before the Physical Society on June 5, by Prof. E. Rutherford, F.R.S.

¹ Abridged from the eleventh "James Forrest" lecture delivered by Mr. W. H. Maw to an Engineering Conference on June 16, at the Institution of Civil Engineers.